

Road Map to Understanding Innovative Technology Options for Brownfields Investigation and Cleanup

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
Technology Innovation Office
Washington, DC 20460

NOTICE

This document has been funded by the United States Environmental Protection Agency (EPA) under Contract 68-W5-0055 to PRC Environmental Management, Inc. The document was subjected to the Agency's administrative and expert review and was approved for publication as an EPA document. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ACKNOWLEDGEMENTS

The Technology Innovation Office (TIO) would like to acknowledge and thank the individuals who reviewed and provided comments on draft documents. The reviewers included representatives of business, community and grassroots organizations, EPA Headquarters and regional offices, local government and city planning offices, and professional associations representing local and state government officials.

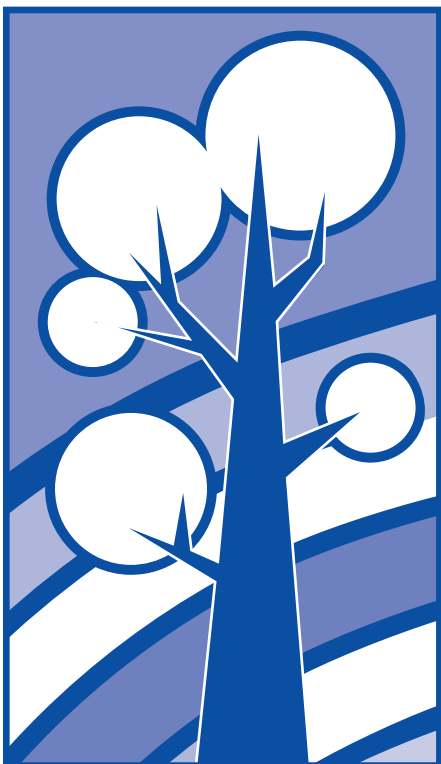
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BACKGROUND



The U.S. Environmental Protection Agency (EPA) has defined Brownfields sites as "abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination." EPA established its Brownfields Economic Redevelopment Initiative to empower states, communities, and other stakeholders involved in economic revitalization to work together to accomplish the redevelopment of such sites. Many states and local jurisdictions also help business and communities adapt environmental cleanup programs to the special needs of Brownfields sites.

Preparing Brownfields sites for productive reuse requires the integration of many elements—financial issues, community involvement, liability considerations, environmental assessment and cleanup, regulatory requirements, and more—as well as coordination among many groups of stakeholders. The assessment and cleanup of a site must be carried out in a way that integrates all those factors into the overall redevelopment process. In addition, the cleanup strategy will vary from site to site. At some sites, cleanup will be completed before the property is transferred to new owners. At other sites, cleanup may take place simultaneously with construction and redevelopment activities. Regardless of when and how cleanup is accomplished, the challenge to any Brownfields program is to clean up sites quickly and redevelop the land in ways that benefit communities and local economies.

Numerous technology options are available to assist those involved in Brownfields cleanup. EPA's Technology Innovation Office (TIO) encourages the use of innovative and cost-effective technologies to characterize and clean up contaminated sites. Innovative technologies for evaluating the nature and extent of contamination and for addressing the cleanup of Brownfields sites hold promise for reducing the cost of cleanup and accelerating the cleanup schedule—potentially producing significant benefits to Brownfields stakeholders by reducing barriers to redevelopment that add to costs, or time schedules, or create uncertainties. When such factors as lower cost, increased environmental

protection, and improved effectiveness are considered, innovative technologies frequently are more cost-effective and provide better and more efficient cleanup than established treatment technologies. Often, they also are more acceptable to communities.

Innovative does not mean unproven. EPA defines an innovative technology as one that has been used in the field but that is not yet considered routinely for use. In addition, cost and performance data on the technologies may be insufficient to encourage managers of cleanup projects to select those technologies over established methods. Nevertheless, innovative technologies are being used in many cleanup programs to assess contamination and to treat a variety of hazardous substances and petroleum products that have been released into the environment. For example, approximately 43 percent of Superfund sites that have contaminated soil are using "innovative" technologies (Innovative Treatment Technologies: Annual Status Report, Eighth Edition).

An **Emerging Technology** is an innovative technology that currently is undergoing bench-scale testing, in which a small version of the technology is tested in a laboratory.

An **Innovative Technology** is a technology that has been field-tested and applied to a hazardous waste problem at a site, but lacks a long history of full-scale use. Information about its cost and how well it works may be insufficient to support prediction of its performance under a wide variety of operating conditions.

An **Established Technology** is a technology for which cost and performance information is readily available. Only after a technology has been used at many different sites and the results fully documented is that technology considered established.



INTRODUCTION

The Road Map to Understanding Innovative Technology Options for Brownfields Investigation and Cleanup focuses on the site characterization and cleanup phase of Brownfields redevelopment. It introduces Brownfields stakeholders to the range of technology options and resources available to them. This Road Map also provides a framework of the logical steps involved in the characterization and cleanup of a Brownfields site in order to link technology options and resources to each of those steps. The Road Map is intended to assist Brownfields stakeholders involved in the selection of technologies in assessing, and, if necessary, addressing contamination at their site.

The Road Map is not an official guidance document. Instead, it draws upon EPA's experiences with Superfund sites, corrective action sites under the Resource Conservation and Recovery Act (RCRA), and UST sites. Specific conditions—such as the kinds and amount of contamination, the proposed reuses of the property, the financial resources available, and the level of support from neighboring communities—vary from site to site. Nevertheless, the Road Map provides a generally applicable outline of the steps involved in the cleanup of a site slated for redevelopment.

The Road Map is intended for the various individuals

involved in or affected by the redevelopment of Brownfields sites. It specifically focuses on those who will make decisions about Brownfields sites but may not be familiar with many of the elements involved in cleaning them up. The document seeks to create an "educated consumer" by introducing the decision makers to the full range of available technology options. In addition, since most Brownfields sites will not be subject to the provisions of such Federally mandated programs as



Superfund, the Road Map introduces Brownfields stakeholders to the steps involved in implementing a cleanup. To better understand those steps, stakeholders should consult as early as possible with the appropriate regulators at the state and, if necessary, at the Federal level. Stakeholders can obtain additional information and assistance by contacting regulatory agencies, as well as by working with reputable technical and legal experts. A qualified site cleanup professional from a reputable consulting and engineering firm also may be employed.

It is important to understand that the cleanup process may not occur in the sequence outlined in the following chapters. At many sites, several activities may be undertaken concurrently with other phases. It is important to consider during each phase the activities and requirements described for subsequent phases, as well as to determine whether activities can be combined or implemented concurrently.

How to Use the Road Map

The four sections of the Road Map summarize the general phases of the cleanup of potentially contaminated sites: site assessment, site investigation, assessment of cleanup options, and design and implementation of the remedy. Each section describes the objective to be accomplished, outlines the key questions to be answered, summarizes the activities undertaken during that phase, lists several information resources available to assist in performing those activities, and points to specific actions to be taken at the completion of the phase. In addition, the section features a brief overview of technologies that can be used during that phase.

Please note that the key questions and activities to be conducted are intended to guide the reader in identifying issues that should be addressed; the Road Map seeks to answer the technology selection questions and is not intended to provide a response to each procedural question identified. To serve as guideposts to the cleanup process, the questions take the point of view of the various groups involved in that process. They ask what stakeholders as a group working together—the “we” of each question—must do as cleanup progresses. The section “Other Important Considerations” discusses additional factors that affect the cleanup of Brownfields sites.

Several appendices also are included to help Brownfields stakeholders understand technical terms and issues related to cleanup. *Appendix A, Guide to Contaminants Found at Typical Brownfields Sites*, identifies activities that may have caused contamination at sites being considered for redevelopment. *Appendix B, Remediation Technologies Screening Matrix*, compares various cleanup technologies against a number of site conditions and considerations. *Appendix C, List of Acronyms and Glossary of Key Terms*, defines specialized terms and acronyms used in discussing and describing Brownfields cleanup efforts. *Appendix D, List of Brownfields and Technical Support Contacts*, provides information about state and EPA regional and technical points of contact. *Appendix E, How to Order Documents*, provides information about ordering the documents listed in the Road Map.

This Road Map is a companion guide to *A Tool Kit of Information Resources for Brownfields Investigation and Cleanup*, also developed by TIO. The Road Map identifies references in the Tool Kit and links them to specific steps in the site assessment, characterization, and cleanup process. The Tool Kit, in turn, describes the resources; provides information about how to obtain resources; introduces Brownfields stakeholders to new approaches and tools for implementing cleanup; and provides a “starter” supply of important information resources. These resources used in tandem should help Brownfields stakeholders understand better the range of technology options available to them.

How to Submit Comments

To help ensure that any future versions of the document meet the needs of its intended audience, EPA invites comments from the members of the Brownfields community. Please submit comments to:

Brownfields Cleanup Road Map
U.S. Environmental Protection Agency
Technology Innovation Office
401 M Street, SW (MC 5102G)
Washington, DC 20460
E-mail: powell.dan@epamail.epa.gov
Fax: (703) 603-9135

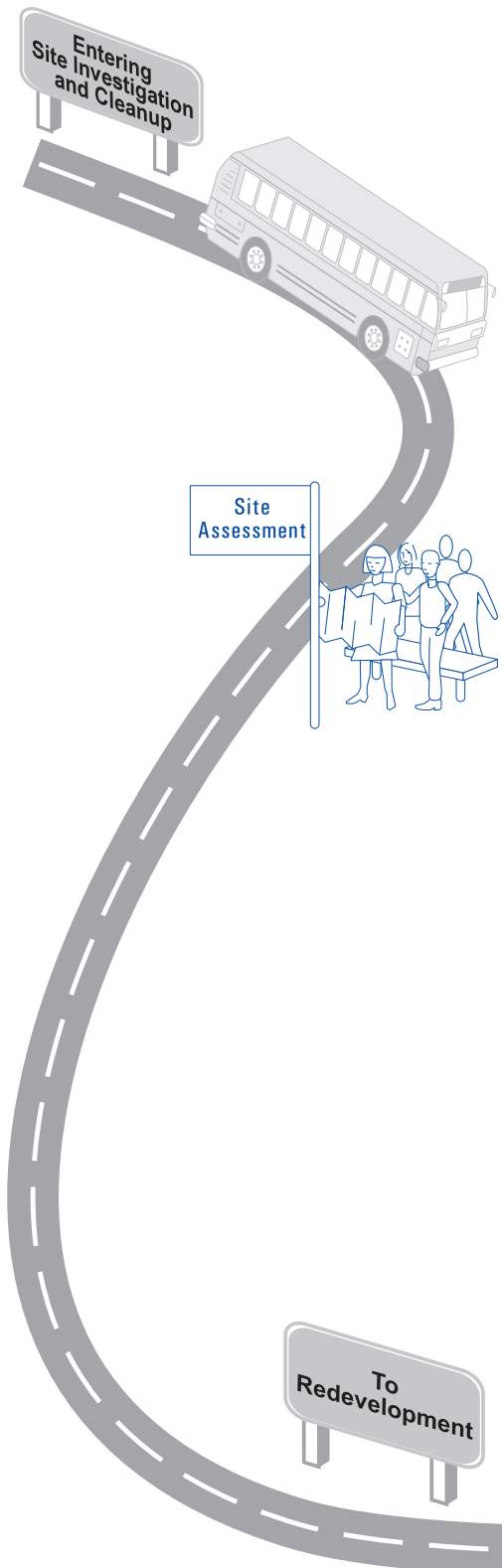
How to Obtain Additional Copies

Additional copies of this document can be obtained from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703)487-4650

When ordering, refer to document number PB97-144810 for the Road Map and document number PB97-144828 for the Tool Kit.

SITE ASSESSMENT



Collect and Assess Information About the Brownfields Site

OBJECTIVE

The purpose of this step is to determine the likelihood of contamination at a particular site by collecting and reviewing applicable information about a site. This "environmental audit" is an initial investigation that usually is limited to a search of historical records. The data to be collected also include information about past and current environmental conditions and historical uses of the site.

During the site assessment phase, it is important to consider the activities and requirements described in the subsequent chapters and determine how they can be combined with or initiated during the site assessment. The collection of data during this initial step of the cleanup process is extremely important for use in identifying and evaluating the applicability of site assessment and cleanup technologies, as well as in determining whether the property can be cleaned to the level necessary for its intended reuse. It also is essential to assess and address the needs and concerns of the community (for example, the development of social and economic profiles and the identification of acceptable environmental risk).

To ensure that sufficient data are collected, the potential applicability of innovative technologies to the site also should be considered. Since much of the work at this stage involves a search of paper and electronic records, applicable technology options may be somewhat limited.

What Do We Need to Know?

KEY QUESTIONS

Factors that should be considered during this phase include:

1. What is known about the site? What records exist that indicate potential contamination and past use of the property? Have other environmental actions occurred (such as notices of violation)? Has an environmental audit been conducted? What level of site assessment is needed to identify the types and extent or the absence of contamination?
2. Is the site located in an area targeted for redevelopment? Is the site being considered for cleanup under a Federal or state Superfund cleanup initiative?
3. Are there Federal, state, local, or tribal regulatory requirements for site assessment? Is there a voluntary cleanup program (VCP)? What agency (Federal, state, local, or tribal)

would be responsible for managing oversight of cleanup?

4. What are the special needs and concerns of the community? How can we encourage community involvement? How will the community make its views known?
5. What environmental conditions will the community accept? What environmental conditions are unacceptable or will hinder redevelopment and the planned reuse?
6. If the site shows evidence of contamination, who and what will be affected? Who will pay for the cleanup?

- Perform a physical or visual examination of the site, including examination of existing structures for structural integrity and asbestos-containing material

- Test for the presence of various contaminants; for example, lead paint, polychlorinated biphenyls (PCB), and radon

- Review the applicability of government oversight programs:

- Identify and consult with the appropriate state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible

- Determine the approach (such as the Superfund program, property transfer laws, or VCPs) that is required or available to facilitate the cleanup of sites

- Identify whether environmental incentives, such as benefits from state VCPs, can be obtained

- Determine whether contamination has been identified previously

- Contact the EPA regional Brownfields coordinator to identify and determine the availability of EPA support programs

- Determine how to incorporate and encourage community participation:

- Identify regulatory requirements

- Assess community interest in the project

- Review any community plans for redevelopment

- Identify future plans for reuse and redevelopment
- Identify factors that may impede redevelopment and reuse
- Begin identifying potential sources for funding site investigation and cleanup activities at the site, if necessary
- Examine unacceptable environmental conditions in terms of initial costs for site improvement and long-term costs for operation and maintenance — include potential cleanup options and constraints

How Do We Find the Answers?*

Activities to be conducted during the initial survey of a site include:

- Determine whether contamination is likely; this process is similar to a Phase I site assessment or environmental audit, during which a records search is performed and the site is visited, but no sampling of soil or groundwater occurs:
 - Identify past owners and the uses they made of the property
 - Review and analyze government and other historical records to identify past use or disposal of hazardous or other waste materials at the site
 - Review Federal and state lists that identify sites that may have environmental contamination; such lists include 1) EPA's Comprehensive Environmental Response, Compensation, and Liability Inventory System (CERCLIS) of potentially contaminated sites, 2) the National Pollutant Discharge Elimination System (NPDES) of permits issued for discharges into surface water, and 3) state records of "emergency removal" actions (for example, the removal of leaking drums or the excavation of explosive waste)
 - Interview property owners, occupants, and others associated with the site, such as previous employees, neighbors, and local planners

ANSWERS

Don't forget to review Other Important Considerations (see page

* Please note that the Road Map seeks to answer the technology selection questions and is not intended to provide a response to each procedural question identified.

that may affect redevelopment, such as project schedules, cost, and potential for achieving the desired reuse.

Where Do We Find Help To Our Technology Questions?



Examples of technology resources that are available to assist in assessing a site are listed below. Although many of the resources are more applicable in later stages of the cleanup process, it may be useful to begin thinking now about options and tools for investigation and cleanup. *Appendix E, How to Order Documents* includes order forms for the resources. Additional information about the resources can be found in the companion document, *A Tool Kit of Information Resources for Brownfields Investigation and Cleanup*.

A. Technology Survey Resources

- Clean-Up Information (CLU-IN) Bulletin Board System (*CLU-IN can be accessed by modem at (301) 589-8366 or by the Internet at <http://clu-in.com>*)
- National Exposure Research Laboratory (NERL)
 - Las Vegas, Site Characterization CD-ROM (EPA 600-C-96-001)

B. Site-Specific Resources

- Contaminants and Remedial Options at Pesticide Sites (EPA 600-R-94-202, PB95-103869)
- Contaminants and Remedial Options at Selected Metal-Contaminated Sites (EPA 540-R-95-512, PB95-271961)
- Contaminants and Remedial Options at Solvent-Contaminated Sites (EPA 600-R-94-203, PB95-177200)
- Contaminants and Remedial Options at Wood Preserving Sites (EPA 600-R-92-182, PB92-232222)
- Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators (EPA 510-B-97-001)

C. Technology-Specific Resources

- Consortium for Site Characterization Technology—Innovative Technology Verification Reports:
 - *Cone Penetrometer/Laser Induced Fluorescence (LIF)*
 - *Rapid Optical Screening Tool (ROST) (EPA 600-R-97-020)*
 - *Site Characterization and Analysis Penetrometer System (SCAPS) (EPA 600-R-97-019)*
 - *Field-Portable X-Ray Fluorescence (FPXRF)*
 - *Portable Gas Chromatograph/Mass Spectrometers (GC/MS)*
- Vendor Field Analytical and Characterization Technologies System (Vendor FACTS), Version 2.0 (*Vendor FACTS can be downloaded from the Internet at <http://www.ttemi.com/visitt> or from the CLU-IN Web site at <http://clu-in.com>*) (Vendor Facts Bulletin EPA 542-N-97-007)

What Technologies Are Available?



The table presented on the next page summarizes several technologies that may be used during the site assessment phase. Because a site assessment focuses on determining the likelihood of contamination, technologies that detect contamination that may be in the air as vapor or particulate matter are listed. If other data indicate that contamination in soil or groundwater may exist, you may want to consider using analytical sampling techniques (as discussed in the next chapter). The information in the table was developed from data in EPA's Vendor FACTS database.

Specific information about the technologies, their effectiveness, and a summary of the contaminants monitored by the technologies can be found in the Vendor FACTS database. See *Appendix C, List of Acronyms and Glossary of Key Terms*, for descriptions of the technologies.

Contaminants Monitored	Applicable Technologies
Ammonia	Gas Monitors
Carbon Monoxide	Colorimetric Detector Tubes; Gas Monitors
Chlorine	Colorimetric Detector Tubes; Gas Monitors
Cyanide Compounds	Colorimetric Detector Tubes; Gas Monitors
Explosives, such as Hydrazine	Gas Monitors
Hydrogen Sulfide	Colorimetric Detector Tubes; Gas Monitors
Mercury	Mercury Vapor Analyzers
Methane	Gas Monitors
Nitrous Oxides	Gas Monitors
Pesticides	Gas Monitors
Radiation	Radiation Meters
Various Volatile Organic Compounds (VOC)	Colorimetric Detector Tubes; Hand-held Photoionization Detectors (PID) or Flame Ionization Detectors (FID)

Where Do We Go From Here?



After completing an initial assessment and survey of the environmental conditions at the site, you may take one of the following courses of action:

Result of Site Assessment	Course of Action
No apparent contamination is found and there is no reason to suspect other media are contaminated. Concerns of stakeholders have been addressed adequately.	<i>Consult with appropriate regulatory officials before proceeding with redevelopment activities.</i>
Contamination is found that poses a significant risk to human health or the environment.	<i>Contact the appropriate Federal, state, local, or tribal government agencies responsible for hazardous waste. Based on feedback of government agency, determine whether redevelopment is an option.</i>
Contamination possibly exists.	<i>Proceed to the SITE INVESTIGATION phase.</i>
Contamination definitely exists, BUT no site investigation has been conducted.	<i>Proceed to the SITE INVESTIGATION phase.</i>
Contamination definitely exists, AND a site investigation has been performed.	<i>Proceed to the SITE INVESTIGATION phase if additional investigation is needed; otherwise, proceed to the CLEANUP OPTIONS phase.</i>

SITE INVESTIGATION



Identify the Source, Nature, and Extent of Contamination

OBJECTIVE

This phase focuses on identifying, locating, and characterizing the nature and extent of contamination at a site. It is essential that an appropriately detailed study of the site be performed to identify the cause, nature, and extent of contamination and the possible threats to the environment or to any people living or working nearby. For Brownfields sites, the results of such a study can be used in determining goals for cleanup, quantifying risks, determining acceptable and unacceptable risk, and developing cleanup plans that do not cause unnecessary delays in the redevelopment and reuse of property.

A site investigation is based on the results of the site assessment, which is discussed in the preceding section of the Road Map. The site investigation phase may include the analysis of samples of soil and soil gas, groundwater, surface water, and sediment. The migration pathways of contaminants also are examined during this phase, and a baseline risk assessment may be needed to calculate risk to human health and the environment.

What Do We Need to Know?

KEY QUESTIONS

If there is evidence of potential or actual contamination, factors that should be considered during the site investigation phase include:

1. Are there Federal, state, local, and tribal regulatory requirements for a site investigation? What agency would be responsible for managing oversight of this phase? What happens if the appropriate agency has not developed standards or guidelines that are suitable for the proposed redevelopment?
2. What technologies are available to facilitate site investigation?
3. Can the need for cleanup be assessed fully and accurately from the information gathered during the site assessment or from a previous site investigation?
4. What environmental conditions does the community consider unacceptable? What issues has the community raised that may affect the site investigation?

5. What are the potential exposure pathways? Who or what could be affected by the contamination or the efforts to clean up the contamination?
6. What happens if significant contamination is found? What happens if contamination poses a "significant threat" to local residents?
7. What happens if the contamination is originating from an adjacent or other off-site source? What happens if background sampling indicates that contamination is originating from a naturally occurring source?
8. Are the infrastructure systems (roads, buildings, sewers, and other facilities) contaminated? Could they be affected by efforts to clean up contamination?

exposure pathways:

- For soil and dust, direct contact, ingestion, or inhalation
- For water, ingestion and inhalation
- For air, inhalation or ingestion

- Determine the proper mix of technologies (such as field measurement technologies that characterize the physical and chemical aspects of the site and fixed laboratory sampling methods) that can facilitate site investigations and meet the required level of data quality (see the definition of data quality objectives [DQO] in *Appendix C, List of Acronyms and Glossary of Key Terms*)
- Examine unacceptable environmental conditions in terms of initial costs for site improvement and long-term costs for annual operation and maintenance — include potential cleanup options and constraints that may affect redevelopment requirements, such as project schedules, costs, and potential for achieving the desired reuse
- Begin consideration of sources of funding for site investigation and cleanup activities
- Consider the use of site-specific risk assessment to determine cleanup levels or guidelines when standards or guidelines have not been developed
- Continue to work with appropriate regulatory agencies to ensure that regulatory requirements are being properly addressed:

How Do We Find the Answers?*

Typical activities that may be conducted during the site investigation phase include:

ANSWERS

- Identify the environmental conditions at the site (for example, by performing a Phase II environmental site assessment that includes tests to confirm the locations of and identities of environmental hazards):
 - Conduct sampling and analysis to determine the nature, extent, source, and significance of the contamination that may be present at the site
 - Conduct sampling and analysis to fully assess the physical and geophysical conditions and characteristics of the site
 - Interpret the results of the analysis to characterize site conditions
 - Determine whether and how (if applicable) the infrastructure systems (including existing structures) are affected by contamination
- Assess the risk the site may pose to human health and the environment. Consider the following

Don't forget to review Other Important Considerations (see page

- Identify and consult with the appropriate state, local, and tribal agencies to include them as early as possible in the decision-making process
- Contact the EPA regional Brownfields coordinator to identify and determine the availability of EPA support programs

- Educate members of the community about the site investigation process and actively involve them in decision making; consider risk communication techniques to facilitate those activities.

* Please note that the Road Map seeks to answer the technology selection questions and is not intended to provide a response to each procedural question identified.

Where Do We Find Help To Our Technology Questions?



Examples of technology resources that provide information to assist in identifying the environmental condition of the site are listed below. *Appendix E, How to Order Documents* includes order forms for the resources. Additional information about the resources can be found in this Road Map's companion document, *A Tool Kit of Information Resources for Brownfields Investigation and Cleanup*.

A. Technology Survey Resources

- National Exposure Research Laboratory (NERL)
- Las Vegas, Site Characterization CD-ROM
(EPA 600-C-96-001)
- Site Characterization and Monitoring: A Bibliography of EPA Information Resources
(EPA 542-B-96-001)
- Status Report on Field Analytical Technologies Utilization: Fact Sheet (EPA 542-R-97-003)

B. Site-Specific Resources

- Expedited Site Assessment Tools for Underground Storage Tank Sites: A Guide for Regulators (EPA 510-B-97-001)

C. Technology-Specific Resources

- Abstract Proceedings: Superfund Technical Support Project General Meeting, Athens, GA, 12/3/90 - 12/6/90 (PB93-205862)
- Characterization of Chromium-Contaminated Soils Using Field-Portable X-ray Fluorescence (PB94-210457)
- Characterization Protocol for Radioactive Contaminated Soils (PB92-963354)
- Consortium for Site Characterization Technology—Innovative Technology Verification Reports:
 - Cone Penetrometer/Laser Induced Fluorescence (LIF)

- *Rapid Optical Screening Tool (ROST)*
(EPA 600-R-97-020)

- *Site Characterization and Analysis Penetrometer System (SCAPS)*
(EPA 600-R-97-019)

- *Field-Portable X-Ray Fluorescence (FPXRF)*
- *Portable Gas Chromatograph/Mass Spectrometers (GC/MS)*

- Development of a Battery-Operated Portable Synchronous Luminescence Spectrofluorometer (PB94-170032)
- DNAPL Site Evaluation (PB93-150217)
- Navy/EPA Technical Screening Matrix
(*under development; available in September 1997*)
- Sampling of Contaminated Sites (PB92-110436)
- Superfund Innovative Technology Evaluation Program - Measuring and Monitoring Program Reports (*See Appendix A, Brownfields Site Cleanup "Starter Kit" in the companion document, A Tool Kit of Information Resources for Brownfields Investigation and Cleanup for a complete list of the reports and the publication numbers*)
- Vendor Field Analytical and Characterization Technologies System (Vendor FACTS), Version 2.0 (*Vendor FACTS can be downloaded from the Internet at <http://www.ttemi.com/visitt> or from the CLU-IN Web site at <http://clu-in.com/>; (Vendor Facts Bulletin EPA 542-N-97-007)*)

What Technologies Are Available



The table presented on the next page summarizes several technologies that may be used during the site investigation phase. The information in the table was developed from information in EPA's Vendor FACTS database. Specific information about the technologies, their effectiveness, and their applicability in relation to detection limits, as well as a summary of the contaminants monitored, can be obtained from the database. EPA's *Superfund Innovative Technology Evaluation (SITE) Program: Technology Profiles* also provides summaries of more than 150 monitoring and measurement technologies. See

Contaminants Monitored	Examples of Field Analytical Technologies
Soils, Sediments, and Sludges	
Geophysical Characteristics of Soil and Bedrock	In Situ Geophysics, Borehole Technologies; Downhole Sensors; Seismic Reflection/Refraction
Buried Objects and Subsurface Anomalies	Ground-Penetrating Radar (GPR); Infrared Monitors; High-Frequency Electromagnetic (EM) Sounding; Subsurface EM; Subsurface Magnetometry; Transient EM Geophysical Instruments
Benzene, Toluene, Ethylbenzene, and Xylene (BTEX)	Colorimetric Test Kits; Immunoassay Test Kits; Laser-induced Fluorescence/Cone Penetrometer; Portable Gas Chromatography/Mass Spectrometry
Explosives	Colorimetric Test Kits; Immunoassay Test Kits; Gas Chromatography/Mass Spectrometry
Mercury	Immunoassay Test Kits; Laser-induced Fluorescence/Cone Penetrometer
Pentachlorophenol (PCP)	Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry
Pesticides	Immunoassay Test Kits
Polychlorinated Biphenyls (PCB)	Colorimetric Test Kits; Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry
Polynuclear Aromatic Hydrocarbons (PAH)	Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry; Soil Gas Analyzers; Chemical Reaction-based Indicators; Biosensors
Total Petroleum Hydrocarbons (TPH)	Colorimetric Test Kits; Immunoassay Test Kits; Laser-induced Fluorescence/Cone Penetrometer; Infrared Monitors
VOCs, Semi-Volatile Organic Compounds (SVOC), Dioxin, Furans	Portable Gas Chromatography/Mass Spectrometry
Groundwater, Surface Water, and Leachate	
Buried Objects	GPR; Transient EM Geophysical Instruments; Subsurface EM; High-Frequency EM Sounding; Subsurface Magnetometry
Metals	X-ray Analyzers; Biosensors
PAHs	Immunoassay Test Kits
Pesticides	Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry; Chemical Reaction-based Indicators
PCBs	Colorimetric Test Kits; Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry
BTEX	Colorimetric Test Kits; Immunoassay Test Kits; Portable Gas Chromatography/Mass Spectrometry
VOCs, SVOCs	Portable Gas Chromatography/Mass Spectrometry
Soil Gas	
VOCs, SVOCs, PCBs, Pesticides, Dioxin, Furans	Portable Gas Chromatography/Mass Spectrometry; Soil Gas Analyzer

Appendix C, List of Acronyms and Glossary of Key Terms, for a description of the technologies.

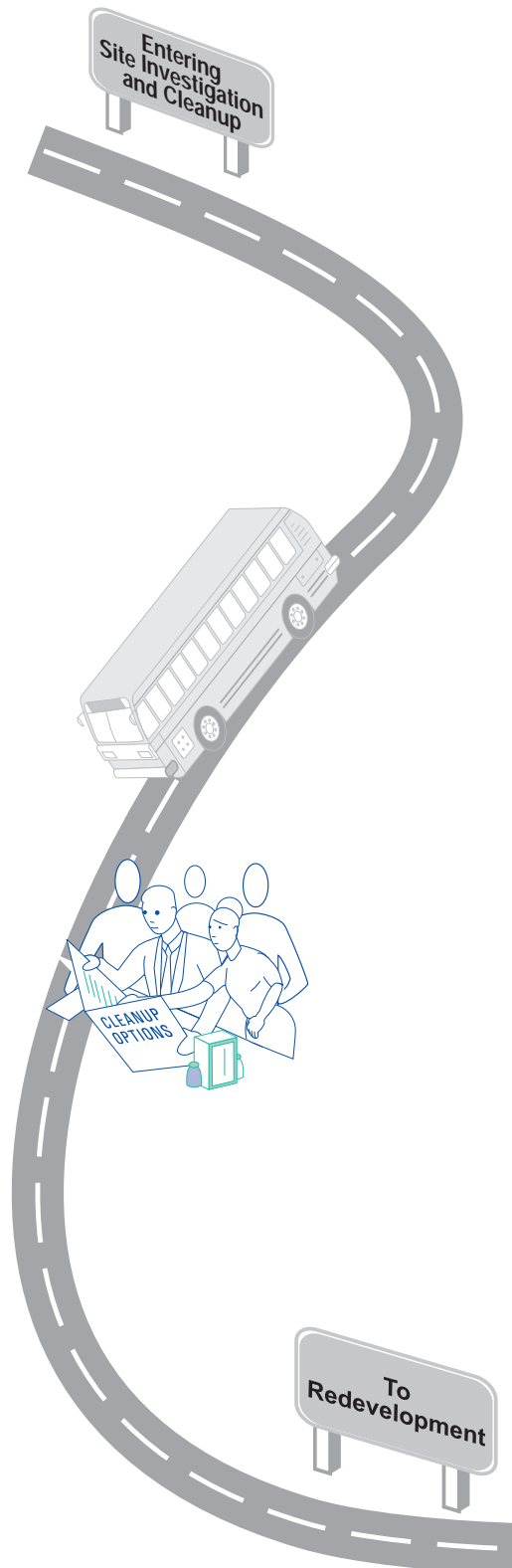
Where Do We Go From Here?

After you have completed your investigation of the environmental conditions at the site, you may take one of the following courses of action:



Results of the Site Investigation		Course of Action
No contamination is found.	➡	<i>Consult with appropriate regulatory officials before proceeding with redevelopment activities.</i>
Contamination is found BUT does not pose a significant risk to stakeholders' human health or the environment.	➡	<i>Consult with appropriate regulatory officials before proceeding with redevelopment activities.</i>
Cleanup of the contamination found probably will require a small expenditure of funds and time.	➡	<i>Proceed to the CLEANUP OPTIONS phase.</i>
Cleanup of the contamination found probably will require a significant expenditure of funds and time. However, contamination does not pose a significant threat to local residents.	➡	<i>Determine whether redevelopment continues to be practicable; if so, proceed to the CLEANUP OPTIONS phase.</i>
Contamination is found that poses a significant threat to local residents.	➡	<i>Contact the appropriate Federal, state, local, or tribal government agencies responsible for hazardous waste.</i>

CLEANUP OPTIONS



Evaluate Applicable Cleanup Alternatives for the Site

OBJECTIVE

The review and analysis of cleanup alternatives rely on the data collected during the site assessment and investigation phases, which are discussed in the preceding sections of the Road Map. The purpose of screening various technologies is to evaluate those technologies for their capability to meet specific cleanup and redevelopment objectives. For Brownfields sites, it also is important to consider budget requirements and to maintain a work schedule so that the project remains profitable.

The role of institutional controls, such as zoning and deed restrictions, posting of safety signs, and efforts to increase community awareness of the environmental conditions and cleanup activities at the site, also is an important consideration during this phase.

What Do We Need to Know?

KEY QUESTIONS

Factors that should be considered during the evaluation of cleanup options include:

1. How do we determine the appropriate and feasible level of cleanup? Are there Federal, state, local, and tribal requirements for cleanup? Are there prescribed standards for cleanup? Are there provisions for using presumptive remedies?
2. What factors are associated with the implementation of cleanup options? Will the cleanup facilitate or hinder the planned redevelopment? How long will cleanup take? What will cleanup cost? What are the short-term and long-term effects of the cleanup technologies under consideration?
3. Are the cleanup options compatible with regional or local planning and development goals and requirements? Can redevelopment activities (such as construction or renovation of buildings) be conducted concurrently with cleanup?
4. How can the community participate in the review and selection of cleanup options? Are the options acceptable in light of community concerns about protection during cleanup and reuse of the site?

5. Is there a need for institutional controls after cleanup? Are proposed institutional controls appropriate in light of community concerns and access to and use of the property?

How Do We Find the Answers?*

The process of reviewing and analyzing cleanup options and technology alternatives usually follows these steps:

ANSWERS

- Establish goals for cleanup
- Educate members of the community about the site cleanup selection process and actively involve them in decision making
- Review general information about technologies to become familiar with cleanup technologies that may be applicable to a particular site:
 - *Conduct searches of existing literature that further describes the technology alternatives*
 - *Analyze detailed technical information about the applicability of technology alternatives*
- Narrow the list of potential alternatives to those technologies that are most appropriate for addressing the contamination identified at the site and that are compatible with the specific conditions of the site and the proposed reuse of the property:
 - *Network with other Brownfields stakeholders and environmental professionals to learn about their experiences and to tap their expertise*
 - *Determine whether sufficient data are available to support identification and evaluation of cleanup alternatives*
 - *Evaluate the options against a number of factors, including toxicity levels, exposure pathways, associated risk, future land use, and economic considerations*
 - *Analyze the applicability of a particular technology to the contamination identified at a site*

Don't forget to review
Other
Important
Considerations
(see page

- *Determine the effects of various technology alternatives on redevelopment objectives*

- Continue to work with appropriate regulatory agencies to ensure that regulatory requirements are addressed properly:

- *Consult with the appropriate state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible*

- *Contact the EPA regional Brownfields coordinator to identify and determine the availability of EPA support programs*

- Integrate cleanup alternatives with reuse alternatives to identify potential constraints on reuse and time schedules and to assess cost and risk factors

• *Select an acceptable remedy that not only addresses the risk of contamination, but also best meets the objectives for redevelopment and reuse of the property and is compatible with the needs of the community*

- *Communicate information about the proposed cleanup option to Brownfields stakeholders, including the affected community.*

Where Do We Find Help To Our Technology Questions?

HELP

Examples of resources that will assist in reviewing and analyzing cleanup options are listed below. *Appendix E, How to Order Documents* includes order forms for the resources. Additional information about the resources can be found in this Road Map's companion document, *A Tool Kit of Information Resources for Brownfields Investigation and Cleanup*.

A. General Technology Program Information

- Clean-Up Information (CLU-IN) Bulletin Board System (CLU-IN can be accessed by modem at (301) 589-8366 or by the Internet at <http://clu-in.com>)
- Clean-Up Information Home Page on the World Wide Web (EPA 542-F-96-011)

* Please note that the Road Map seeks to answer the technology selection questions and is not intended to provide a response to each procedural question identified.

- Conducting Treatability Studies Under RCRA (OSWER Directive 9380.3-09FS, PB92-963501)
- Superfund Innovative Technology Evaluation Program: Emerging Technology Program (EPA 540-F-95-502)
- Superfund Innovative Technology Evaluation Program: Fact Sheet (EPA 542-F-95-009)
- Technology Transfer Highlights (EPA 625-N-96-001)

B. Technology Survey Resources

General

- Abstracts of Remediation Case Studies (EPA 542-R-95-001, PB95-201711)
- Accessing Federal Data Bases for Contaminated Site Clean-Up Technologies, Fourth Edition (EPA 542-B-95-005, PB96-141601)
- Alternative Treatment Technology Information Center (ATTIC) (*The ATTIC database can be accessed by modem at (703) 908-2138*)
- Bibliography for Innovative Site Clean-Up Technologies (EPA 542-B-96-003)
- Completed North American Innovative Technology Demonstration Projects (EPA 542-B-96-002, PB96-153127)
- Federal Publications on Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation, Fifth Edition (EPA 542-B-95-004, PB96-145099)
- Guide to Documenting Cost and Performance for Remediation Projects (EPA 542-B-95-002, PB95-182960)
- Innovative Treatment Technologies: Annual Status Report, Eighth Edition (EPA 542-R-96-010)
- Innovative Treatment Technologies: Annual Status Report Database (ITT Database) (*ITT can be downloaded from the CLU-IN Web site at <http://clu-in.com> or from ATTIC or America Online*)

- Remediation Case Studies: Fact Sheet and Order Form (EPA 542-F-95-003)
- Remediation Technologies Screening Matrix and Reference Guide, Second Edition (PB95-104782; Fact Sheet EPA 542-F-95-002)
- Selected Alternative and Innovative Treatment Technologies for Corrective Action and Site Remediation: A Bibliography of EPA Information Resources (EPA 542-B-95-001)
- Superfund Innovative Technology Evaluation Program: Technology Profiles, Ninth Edition (EPA 540-R-97-502)
- Synopses of Federal Demonstrations of Innovative Site Remediation Technologies, Third Edition (EPA 542-B-93-009, PB94-144565)
- Technology Preselection Data Requirements: Engineering Bulletin (EPA 540-S-92-009, PB93-105591)
- Vendor Information System for Innovative Treatment Technologies (VISITT), Version 5.0 (*VISITT can be downloaded from the Internet at <http://www.ttemi.com/visitt> or from the CLU-IN Web site at <http://clu-in.com>*)(VISITT Bulletin EPA 542-N-96-006)

Sites/Waste Types

METALS

- In Situ Treatment of Metal Contaminated Soils (EPA 542-R-96-001)
- Literature Review Summary of Metals Extraction Processes Used to Remove Lead From Soils: Project Summary (EPA 600-SR-94-006)
- Recent Developments for In Situ Treatment of Metal Contaminated Soils (EPA 542-R-97-004)
- Selection of Control Technologies for Remediation of Lead Battery Recycling Sites: Engineering Bulletin (EPA 540-S-91-014, PB93-121333)

POLYCHLORINATED BIPHENYLS (PCBs)

- ➡ Technology Alternatives for the Remediation of PCB-Contaminated Soil and Sediment (EPA 540-S-93-506)

UNDERGROUND STORAGE TANKS

- ➡ How to Effectively Recover Free Product at Leaking Underground Storage Tank Sites: A Guide for State Regulators (EPA 510-F-96-001; Fact Sheet EPA 510-F-96-005)
- ➡ How to Evaluate Alternative Cleanup Technologies for Underground Storage Tank Sites: A Guide for Corrective Action Plan Reviewers (EPA 510-B-94-003, S/N 055-000-00499-4; Pamphlet EPA 510-F-95-003)
- ➡ Introducing TANK Racer (EPA 510-F-96-001)
- ➡ Overview of UST Remediation Options (EPA 510-F-93-029)

WOOD PRESERVING/TREATMENT

- ➡ Superfund Innovative Technology Evaluation (SITE) Program: Technology Profiles, Seventh Edition (EPA 540-R-94-526, PB95-183919)

C. Technology-Specific Resources**Community Outreach**

- ➡ Citizen's Guides to Understanding Innovative Treatment Technologies. *(The second document number listed after each title below is the document number for the guide in Spanish)*
 - Bioremediation (EPA 542-F-96-007, EPA 542-F-96-023)
 - Chemical Dehalogenation (EPA 542-F-96-004, EPA 542-F-96-020)
 - In Situ Soil Flushing (EPA 542-F-96-006, EPA 542-F-96-022)
 - Innovative Treatment Technologies for Contaminated Soils, Sludges, Sediments, and Debris (EPA 542-F-96-001, EPA 542-F-96-017)

- Phytoremediation (EPA 542-F-96-014, EPA 542-F-96-025)

- Soil Vapor Extraction and Air Sparging (EPA 542-F-96-008, EPA 542-F-96-024)

- Soil Washing (EPA 542-F-96-002, EPA 542-F-96-018)

- Solvent Extraction (EPA 542-F-96-003, EPA 542-F-96-019)

- Thermal Desorption (EPA 542-F-96-005, EPA 542-F-96-021)

- Treatment Walls (EPA 542-F-96-016, EPA 542-F-96-027)

Superfund Innovative Technology Evaluation (SITE) Program

See Appendix A, Brownfields Site Cleanup "Starter Kit" in the companion document, A Tool Kit of Information Resources for Brownfields Investigation and Cleanup for a complete list of the reports and the publication numbers.

- ➡ Superfund Innovative Technology Evaluation Program - Demonstration Program Reports
- ➡ Superfund Innovative Technology Evaluation Program - Measuring and Monitoring Program Reports

Bioremediation

- ➡ Bioremediation Field Evaluation: Champion International Superfund Site, Libby, Montana (EPA 540-R-96-500)
- ➡ Bioremediation Field Evaluation: Eielson Air Force Base, Alaska (EPA 540-R-95-533)
- ➡ Bioremediation Field Initiative Site Profiles:
 - Libby Ground Water Superfund Site, Montana (EPA 540-F-95-506A)
 - Eielson Air Force Base, Alaska (EPA 540-F-95-506B)
 - Escambia Wood Preserving Site, Florida (EPA 540-F-95-506G)

- *Hill Air Force Base Superfund Site, Utah (EPA 540-F-95-506C)*
- *Public Service Company of Colorado, Colorado (EPA 540-F-95-506D)*
- *Reilly Tar and Chemical Corporation, Minnesota (EPA 540-F-95-506H)*
- Bioremediation in the Field Search System (EPA 540-F-95-507; Fact Sheet EPA 540-F-94-506)
- Bioremediation Resource Guide (EPA 542-B-93-004, PB94-112307)
- EPA Engineering Bulletins:
 - *Composting (EPA 540-S-96-502)*
 - *In Situ Biodegradation Treatment (EPA 540-S-94-502, PB94-190469)*
 - *Rotating Biological Contactors (EPA 540-S-92-007)*
 - *Slurry Biodegradation (EPA 540-2-90-016, PB91-228049)*
- In Situ Bioremediation of Contaminated Ground Water (EPA 540-S-92-003, PB92-224336)
- In Situ Bioremediation of Ground Water and Geological Material: A Review of Technologies (EPA 600-SR-93-124, PB93-215564)
- Remediation Case Studies: Bioremediation (EPA 542-R-95-002, PB95-182911)

Groundwater Treatment

- Emerging Abiotic In Situ Remediation Technologies for Ground Water and Soil: Summary Report (EPA 542-S-95-001, PB95-239299)
- Evaluation of Technologies for In Situ Cleanup of DNAPL Contaminated Sites (EPA 600-R-94-120, PB94-195039)
- Ground-Water Remediation Technologies Analysis Center (GWRTAC) (*GWRTAC can be accessed by the Internet at <http://www.gwrtac.org>*)
- Ground-Water Treatment Technology Resource Guide (EPA 542-B-94-009, PB95-138657)

- In Situ Bioremediation of Contaminated Ground Water (EPA 540-S-92-003, PB92-224336)
- In Situ Bioremediation of Ground Water and Geological Material: A Review of Technologies (EPA 600-SR-93-124, PB93-215564)
- Light Nonaqueous Phase Liquids (EPA 540-S-95-500, PB95-267738)
- Remediation Case Studies: Groundwater Treatment (EPA 542-R-95-003, PB95-182929)
- Status Reports on In Situ Treatment Technology Demonstration and Applications:
 - *Altering Chemical Conditions (EPA 542-K-94-008)*
 - *Cosolvents (EPA 542-K-94-006)*
 - *Electrokinetics (EPA 542-K-94-007)*
 - *Hydraulic and Pneumatic Fracturing (EPA 542-K-94-005)*
 - *Surfactant Enhancements (EPA 542-K-94-003)*
 - *Thermal Enhancements (EPA 542-K-94-009)*
 - *Treatment Walls (EPA 542-K-94-004)*

Physical and Chemical Treatment

- EPA Engineering Bulletins:
 - *Chemical Dehalogenation Treatment: APEG Treatment (EPA 540-2-90-015, PB91-228031)*
 - *Chemical Oxidation Treatment (EPA 540-2-91-025, PB92-180066)*
 - *In Situ Soil Flushing (EPA 540-2-91-021, PB95-180025)*
 - *In Situ Vitrification Treatment (EPA 540-S-94-504, PB95-125499)*
 - *Solidification/Stabilization of Organics and Inorganics (EPA 540-S-92-015)*
 - *Supercritical Water Oxidation (EPA 540-S-92-006, PB92-224088)*
- Physical/Chemical Treatment Technology Resource Guide (EPA 542-B-94-008, PB95-138665)

- Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification (EPA 542-R-95-005, PB95-182945)
- Soil Washing Treatment: Engineering Bulletin (EPA 540-2-90-017, PB91-228056)
- Solvent Extraction Treatment: Engineering Bulletin (EPA 540-S-94-503, PB94-190477)

Soil Vapor Extraction and Enhancements

- EPA Engineering Bulletins:
 - *In Situ Soil Vapor Extraction Treatment* (EPA 540-2-91-006, PB91-228072)
 - *In Situ Steam Extraction Treatment* (EPA 540-2-91-005, PB91-228064)
- Remediation Case Studies: Soil Vapor Extraction (EPA 542-R-95-004, PB95-182937)
- Soil Vapor Extraction (SVE) Enhancement Technology Resource Guide: Air Sparging, Bioventing, Fracturing, and Thermal Enhancements (EPA 542-B-95-003)
- Soil Vapor Extraction (SVE) Treatment Technology Resource Guide (EPA 542-B-94-007)

Thermal Treatment

- EPA Engineering Bulletins:
 - *Mobile/Transportable Incineration Treatment* (EPA 540-2-90-014, PB91-228023)
 - *Pyrolysis Treatment* (EPA 540-S-92-010)
 - *Thermal Desorption Treatment* (EPA 540-S-94-501, PB94-160603)
- Remediation Case Studies: Thermal Desorption, Soil Washing, and In Situ Vitrification (EPA 542-R-95-005, PB95-182945)

table is designed to facilitate comparisons between different technologies and different types of contaminants.

The information in the table is based on data in EPA's VISITT database as well as the Remediation Technologies Screening Matrix and Reference Guide (see *Appendix B* for a copy of the complete matrix). The technologies listed in the table were rated "better" in treating the selected contaminant groups. See *Appendix C, List of Acronyms and Glossary of Key Terms*, for descriptions of the technologies.

Contaminants Monitored	Examples of Technologies
Soils, Sediments, and Sludges	
VOCs	Ex Situ Bioremediation; In Situ Bioremediation (Biodegradation); In Situ Soil Flushing; Soil Vapor Extraction
SVOCs	Incineration; In Situ Bioremediation (Biodegradation); Soil Washing; Solvent Extraction; Thermal Desorption
Fuels	Ex Situ Bioremediation; Incineration; In Situ Bioremediation (Biodegradation); Soil Washing; Soil Vapor Extraction
Inorganic Compounds	Ex Situ Soil Flushing; Soil Washing; Solidification/Stabilization
Explosives	Ex Situ Bioremediation; Incineration; In Situ Bioremediation (Biodegradation); Soil Washing; Solvent Extraction
Groundwater, Surface Water, and Leachate	
VOCs	Air Sparging; Dual-Phase Extraction; In Situ Air Sparging; In Situ Bioremediation Oxygen Enhancement with Air Sparging; In Situ Bioremediation Oxygen Enhancement with H_2O_2 ; Passive Treatment Wall; Pump and Treat Air Stripping; Pump and Treat Biological Reactor; Pump and Treat Carbon Adsorption
SVOCs	In Situ Bioremediation Oxygen Enhancement with Air Sparging; In Situ Bioremediation Oxygen Enhancement with H_2O_2 ; Passive Treatment Wall; Pump and Treat Biological Reactor; Pump and Treat Carbon Adsorption
Fuels	Air Sparging; Dual-Phase Extraction; In Situ Air Sparging; In Situ Bioremediation Oxygen Enhancement with Air Sparging; In Situ Bioremediation Oxygen Enhancement with H_2O_2 ; Pump and Treat Biological Reactor
Inorganic Compounds	Passive Treatment Wall; Pump and Treat Filtration; Pump and Treat Ion Exchange
Explosives	Passive Treatment Wall; Pump and Treat Carbon Adsorption

What Technologies Are Available?



The table to the right identifies several innovative technologies used to treat soil and groundwater. The technologies identified treat contaminants in very different ways. In addition, a site often is contaminated by more than one type of contaminant. As such, the

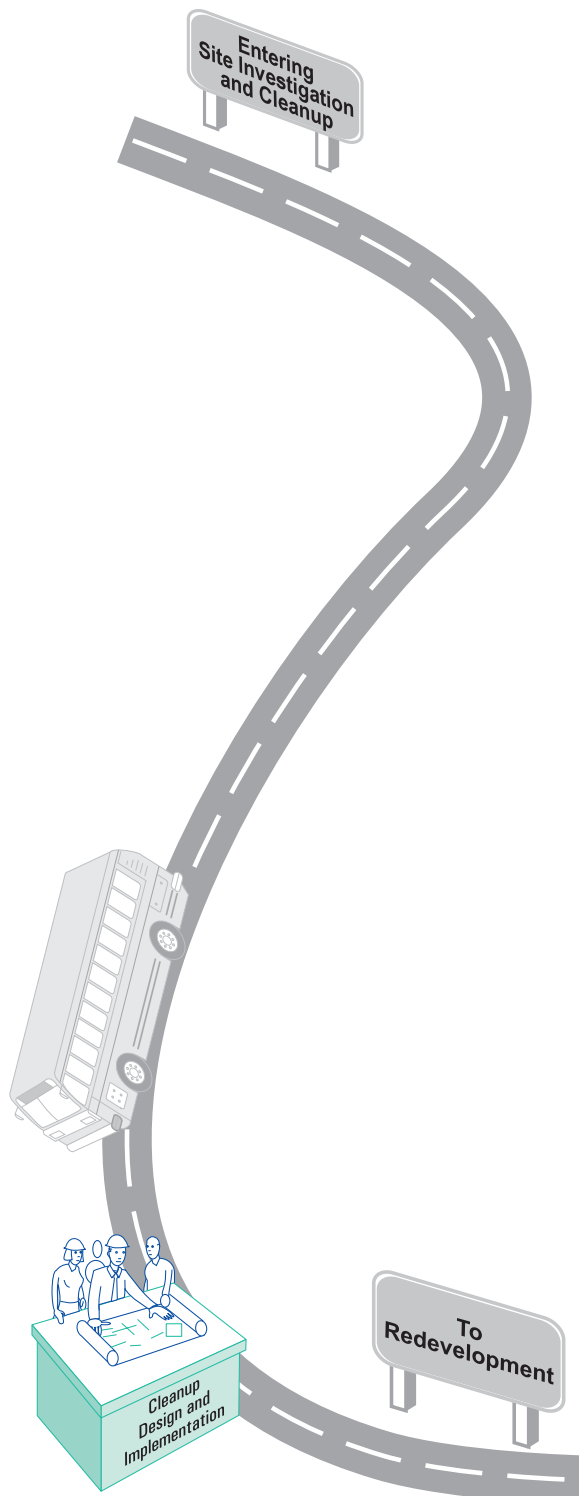
Where Do We Go From Here?



After you have reviewed options for cleanup, you may take any of the following courses of action:

Result of the Review of Cleanup Options		Course of Action
The proposed cleanup option appears feasible.	➡	<i>Proceed to the CLEANUP DESIGN AND IMPLEMENTATION phase.</i>
No cleanup option appears feasible in light of the proposed redevelopment and land reuse needs (such as project milestones and cost and intended reuse).	➡	<i>Determine whether revising redevelopment plans remains a practicable option; if so, proceed to the CLEANUP DESIGN AND IMPLEMENTATION phase. If contamination exists at considerable levels, consider other waste programs.</i>

CLEANUP DESIGN AND IMPLEMENTATION



Develop and Carry Out Detailed Cleanup Plans for the Site

OBJECTIVE

This phase focuses on the design and implementation of a cleanup plan to prepare the property for redevelopment and reuse. The design of the cleanup plan and implementation of the technology options selected in the previous phase involves close coordination with all other redevelopment efforts in the immediate vicinity of the site.

What Do We Need to Know?

KEY QUESTIONS

Factors that should be considered during the design and implementation of cleanup activities include:

1. Are there Federal, state, local, and tribal requirements for conducting cleanup activities?
2. How will cleanup be monitored so that work can be stopped when cleanup goals are reached?
3. How best can the community participate in the design and implementation of the cleanup plan?
4. What can be done to protect the community and other property during cleanup?
5. What are the tradeoffs between cost and meeting redevelopment project deadlines? Can redevelopment activities (such as renovation of existing buildings and construction of roads and sewage systems) be performed concurrently with cleanup activities?
6. Will institutional controls facilitate or hinder redevelopment?

How Do We Find the Answers?*

ANSWERS

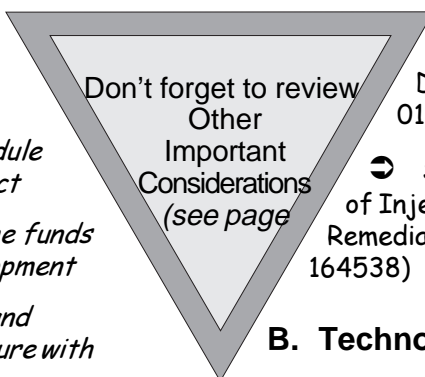
Typical activities that may be conducted during this phase include:

- Review all applicable Federal, state, local, and tribal regulatory guidelines and regulations to

** Please note that the Road Map seeks to answer the technology selection questions and is not intended to provide a response to each procedural question identified.*

ensure compliance, including guidelines for state VCPs

- Continue to work with the appropriate regulatory agencies to ensure that regulatory requirements are being properly addressed
 - *Consult with the appropriate state, local, and tribal regulatory agencies to include them in the decision-making process as early as possible*
 - *Contact the EPA regional Brownfields coordinator to identify and determine the availability of EPA support programs*
- Identify all environmental requirements that must be met and the levels of environmental incentives that apply
- Develop one or more conceptual plans for cleanup and subsequent monitoring that incorporate technology options and consider the effect of any cleanup activities on the proposed reuse of the property and the schedule for project design or construction:
 - *Develop or review the schedule for completion of the project*
 - *Obtain a final figure for the funds available for project development*
 - *Coordinate the renovation and construction of infrastructure with cleanup activities*
 - *Coordinate activities with developers, financiers, construction firms, and members of the local community*
- Establish contingency plans to address the discovery of additional contamination during cleanup
- Develop procedures for community participation, for example, by working with community advisory boards or local redevelopment authorities
- Implement and monitor the cleanup plan and performance of the remedy selected
- Work with county or local officials to facilitate the placement and implementation of institutional controls, including ongoing monitoring and enforcement of these controls.



Where Do We Find Help To Our Technology Questions?

Examples of technology resources that provide information about applicable regulatory guidelines and regulations and community outreach materials are listed below. In addition, technologies identified during the site investigation phase may be appropriate to monitor cleanup performance and close-out. *Appendix E, How to Order Documents* includes order forms for the resources. Additional information about the resources can be found in the Road Map's companion document, *A Tool Kit of Information Resources for Brownfields Investigation and Cleanup*.



A. General Technology Program Information

- Initiatives to Promote Innovative Technology in Waste Management Programs (OSWER Directive 9380.0-25, EPA 540-F-96-012)
- State Policies Concerning the Use of Injectants for In Situ Ground Water Remediation (EPA 542-R-96-001, PB96-164538)

B. Technology Survey Resources

- Vendor Information System for Innovative Treatment Technologies (VISITT), Version 5.0 (*VISITT can be downloaded from the Internet at <http://www.ttemi.com/visitt> or from the CLU-IN Web site at <http://clu-in.com>*)

C. Technology-Specific Resources

- Citizen's Guides to Understanding Innovative Treatment Technologies. (*The second document number listed after each title below is the document number for the guide in Spanish*)
 - *Bioremediation (EPA 542-F-96-007, EPA 542-F-96-023)*
 - *Chemical Dehalogenation (EPA 542-F-96-004, EPA 542-F-96-020)*
 - *In Situ Soil Flushing (EPA 542-F-96-006, EPA 542-F-96-022)*

- *Innovative Treatment Technologies for Contaminated Soils, Sludges, Sediments, and Debris* (EPA 542-F-96-001, EPA 542-F-96-017)
- *Phytoremediation* (EPA 542-F-96-014, EPA 542-F-96-025)
- *Soil Vapor Extraction and Air Sparging* (EPA 542-F-96-008, EPA 542-F-96-024)
- *Soil Washing* (EPA 542-F-96-002, EPA 542-F-96-018)
- *Solvent Extraction* (EPA 542-F-96-003, EPA 542-F-96-019)
- *Thermal Desorption* (EPA 542-F-96-005, EPA 542-F-96-021)
- *Treatment Walls* (EPA 542-F-96-016, EPA 542-F-96-027)

☛ Technology Resource Guides:

- *Bioremediation Resource Guide* (EPA 542-B-93-004, PB94-112307)
- *Ground-Water Treatment Technology Resource Guide* (EPA 542-B-94-009, PB95-138657)
- *Physical/Chemical Treatment Technology Resource Guide* (EPA 542-B-94-008, PB95-138665)
- *Soil Vapor Extraction (SVE) Enhancement Technology Resource Guide: Air Sparging, Bioventing, Fracturing, and Thermal Enhancements* (EPA 542-B-95-003)
- *Soil Vapor Extraction (SVE) Treatment Technology Resource Guide* (EPA 542-B-94-007)

☛ WASTECH Series of Innovative Site Remediation Technology Engineering Monographs:

- *Bioremediation*
- *Chemical Treatment*
- *Soil Washing/Soil Flushing*
- *Solidification/Stabilization*
- *Solvent/Chemical Extraction*
- *Thermal Desorption*
- *Thermal Destruction*
- *Vacuum Vapor Extraction*

Where Do We Go From Here?



After you have completed cleanup, you may take one of the following courses of action:

Result of Cleanup		Course of Action
Contamination has been removed, contained, or controlled.	➡	<i>Consult with the appropriate regulatory officials before proceeding with redevelopment activities.</i>
Additional contamination has been discovered.	➡	<i>Continue cleanup activities. However, you may have to return to the SITE INVESTIGATION phase to determine the extent and nature of the contamination.</i>
Long-term monitoring of cleanup and performance of the technology is required.	➡	<i>Return to the SITE INVESTIGATION phase to collect after-performance samples for monitoring cleanup.</i>

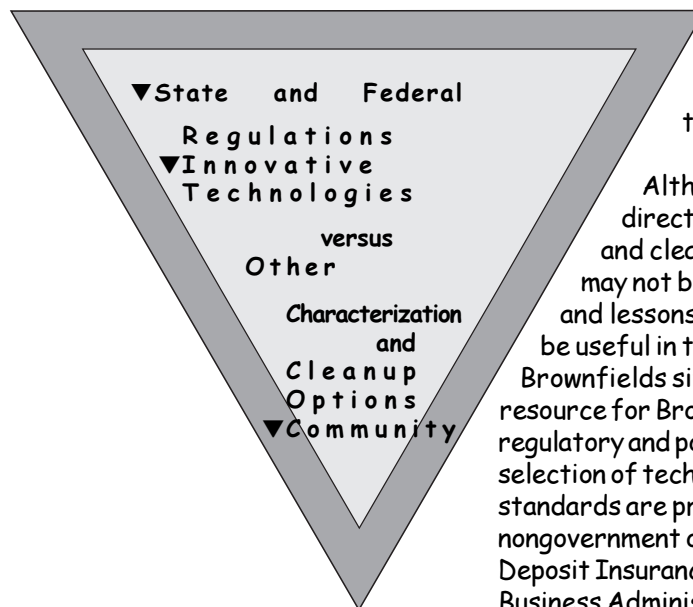
OTHER IMPORTANT CONSIDERATIONS

Understanding Regulatory Guidelines and Regulations

Understanding the applicable regulatory guidelines and regulations is crucial to selecting the appropriate technologies for cleaning up a Brownfields site. It is important to note that many Brownfields sites will be managed under state regulatory authorities.

Therefore, the state regulatory authority will specify many of the requirements for, and steps in, site assessment, site investigation, the selection of cleanup options, and the design and implementation of cleanup. State regulatory agencies should be consulted to determine what, if any, site specific requirements may exist. State regulators also can help to identify other regulatory guidelines and regulations (such as applicable Federal statutes) that also may affect the site. For these reasons, it is

important to remain in constant contact with state regulatory agencies, as well as any other appropriate regulatory agencies, throughout the cleanup process.



Although compliance with official policy directives under other Federal regulatory and cleanup programs, such as Superfund, may not be required, some of the information and lessons learned under such programs may be useful in the investigation and cleanup of Brownfields sites. EPA also can be a valuable resource for Brownfields stakeholders by providing regulatory and policy support to facilitate the selection of technologies. Other guidance and standards are promulgated by government and nongovernment organizations, such as the Federal Deposit Insurance Corporation (FDIC) the Small Business Administration (SBA), and the American Society for Testing and Materials (ASTM). The box on the next page provides descriptions of the various EPA hotlines for statutory and regulatory programs.

HOTLINES AND OTHER SERVICES

Center for Environmental Research Information (CERI).

CERI is the focal point for the exchange of scientific and technical environmental information produced by EPA. CERI publishes brochures, capsule and summary reports, handbooks, newsletters, project reports, and manuals. The center operates daily, Monday through Friday, 8:00 a.m. to 4:30 p.m. eastern standard time (EST). The center can be reached by telephone at 513-569-7391.

Resource Conservation and Recovery Act/Underground Storage Tanks (RCRA/UST), Superfund, and Emergency Planning and Community Right-to-Know Act (EPCRA) Hotline.

This hotline provides information about the RCRA/UST, Superfund, and EPCRA programs. The hotline handles information about EPA's RCRA regulations and programs implemented under RCRA, the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), EPCRA, and the Superfund Amendments Reauthorization Act (SARA) Title III. The hotline also provides referrals for obtaining related documents concerning the RCRA, UST, Superfund/CERCLA, and Pollution Prevention/Waste Minimization programs. Translation is available for Spanish-speaking callers. The hotline operates daily Monday through Friday, 9:00 a.m. to 6:00 p.m. EST. The hotline can be reached by telephone at 800-424-9346 for all nongovernment locations outside the Washington, DC metropolitan local calling area, or 703-412-9810 for all locations in the Washington, DC metropolitan local calling area.

Resource Conservation and Recovery Act Docket and Information Center (RIC).

The RIC provides public access to all regulatory materials supporting EPA's actions under RCRA and disseminates publications from EPA's Office of Solid Waste and Emergency Response. The information center operates daily, Monday through Friday, 9:00 a.m. to 4:00 p.m. EST. The information center can be reached by telephone at 703-603-9230.

Superfund Docket and Information Center.

The Superfund Docket and Information Center provides access to Superfund regulatory documents, Superfund Federal Register Notices, and Records of Decision (ROD). The center operates daily, Monday through Friday, 9:00 a.m. to 4:00 p.m. EST. The center can be reached by telephone at 703-603-8917 or by facsimile at 703-603-9133.

TechDirect.

TechDirect is a free electronic mail service that highlights new publications and events of interest to site cleanup professionals. Approximately once a month, EPA's Technology Innovation Office (TIO) sends subscribers an e-mail message announcing the availability of publications and the scheduling of events. The message also directs subscribers to sources from which they can obtain more information. Contact Mr. Jeff Heimerman at 703-603-7191 or by e-mail at heimerman.jeff@epamail.epa.gov for more information.

Toxic Substances Control Act (TSCA) Assistance Information Service.

The information service provides information about regulations under TSCA to the chemical industry, labor and trade organizations, environmental groups, and the general public. Technical as well as general information is available. The information service operates daily, Monday through Friday, 8:30 a.m. to 5:00 p.m. EST. The information service can be reached by telephone at 202-554-1404.

Comparing Innovative Technologies to Other Characterization and Cleanup Options

The Road Map focuses on innovative characterization and treatment options. Although the Road Map emphasizes the use of innovative technologies to address contamination, the use of other technologies also should be considered. For example, containment or more standard technology options also may be appropriate to address contamination at Brownfields sites. Examples of containment technologies include dynamic compaction, landfill reuse, and stabilization or solidification of contaminated material. Established technologies, such as incineration and pump-and-treat processes for groundwater contamination, also are alternatives to innovative technologies for use in addressing contamination.

When deciding between innovative and established technologies or between treatment and containment technologies, Brownfields stakeholders should compare the effectiveness and efficiency of each technology against the specific needs of the individual site and stakeholders. During this analysis, one should remember that technologies, or at least our understanding of them, change constantly.

Seeking External Support (Community Relations and Professional Support)

A wealth of information and expertise related to site cleanup is readily available. It is important that members of the Brownfields community have access to that information and are able to draw upon lessons learned to benefit from the experience of others.

Most decision makers at Brownfields sites will require technical and legal assistance to fully understand the complexities of investigating and cleaning up a contaminated site. In fact, some states may require the participation of certified or licensed professionals to help guide the site investigation and cleanup process. State regulatory agencies should be consulted to determine the requirements, if any, for the participation of certified or licensed cleanup professionals. It is recommended that site cleanup professionals and legal and other experts be recruited as members of the Brownfields team.

The Brownfields community can benefit from EPA's assistance in directing its members to appropriate resources and providing opportunities to network and participate in the sharing of information. A number of electronic bulletin boards and databases, newsletters, and reports provide opportunities for Brownfields stakeholders to network with other stakeholders to identify information about site cleanup and technology options.